Space Weather Technical Forecast

Issued on Monday 24 February 2025 at 13:12 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: M-class flares likely. Possible glancing CME Day 1 (24 Feb), chance of G1.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been High with one X-flare, peaking at X2.0 at 23/1927 UTC, most likely from AR4001 over the NW limb, while AR4001 may not be visible on the Earth-facing disc it may still produce notable flares for the next 6-12 hours. AR3991 has now rotated of the western limb, but potentially still posing a flare risk for the next 24 hours. Otherwise, the most notable regions remain AR3998 in the southwest quadrant and AR4000 in the northwest quadrant. AR3998 has shown spot development, increasing in penumbral area, and an increase intermediate spots with mixed polarities. However, it does not currently have a clear delta spot. AR4000 developed rapidly at first although this has now stalled, showing little change in the last 12 hours with some slight decay in its intermediate spots and its delta spot weakening. AR3996 continues to appear to be in slight decay. The other regions on the disc do not currently appear particularly complex.

A CME was observed off the northwest limb in association with the X2.0 flare, but is unlikely to have any Earth-directed impact. A second CME left the Sun around 24/0702 UTC most likely associated with the M3.3 flare from AR4000 but with the potential to also contain remnants of a filament that appeared to lift of just to the north of AR3998. Further analysis is needed, but this may glance the Earth on 26 Feb.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by ACE at L1, showed background conditions. Wind speeds varied between 300-360 km/s. Density was initially below average, rising to average late on 23 Feb. Interplanetary Magnetic Field, Bt, was initially weak at or below 8nT with a possible transient CME arrival around 23/2130 UTC bringing a rise to 15 nT. The north-south component, Bz, was initially predominately weakly positive, around +1 to +5nT with a negative interval between 23/2030 UTC and 23/2345 UTC down to -9nT. It then trended back to moderately positive until 24/0730 UTC when it became variable and weak -6nT to +6nT. Phi angle was initially predominantly positive (away from the Sun) before trending negative (towards the Sun) from 24/0900 UTC. Geomagnetic activity was Quiet to Unsettled (Kp1-3).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES18 was near or just very slightly above normal background levels up to 1pfu. High energy electron flux (greater than 2MeV) at GOES16 was at moderate to background levels. The associated 24-hour

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fluence was below the Active threshold (1e8 integrated pfu) on a slight declining trend, recording 4.76e6 integrated pfu at 24/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate solar activity is forecast, with occasional M-flares considered likely and a slight chance of isolated X-flares.

Solar Wind / Geomagnetic Activity: There are two main CMEs in the forecast at present. The first arriving on 24 Feb with a chance of G1/Minor storms and a slight chance of G2/Moderate storm intervals. Solar Orbiter shows this CME may be stronger than the one that may have glanced Earth in the early hours of 24 Feb, which saw an Unsettled geomag interval. However, this is subject to significant uncertainly as Solar Orbiter sits close to Venus, behind Earths Orbit, which may mean the CME passes behind Earth. The second is still waiting further analysis, but potentially glancing Earth on Day 3 (26 Feb). Wind speeds are currently at background levels. Late Day 1 or Day 2 (24-25 Feb) a slight enhancement may occur, associated with CH17/-, with wind speeds perhaps reaching around 400-450 km/s.

Geomagnetic activity is forecast to be Unsettled to Active (Kp3-4), with a chance of G1/Minor storm (Kp5) and a slight chance of G2/Moderate storm (Kp6) intervals, on Day 1 (24 Feb) however this is generally low confidence due to the uncertainly in the arrival of the CME. Activity then gradually easing back to Quiet to Unsettled by Day 2 (25 Feb). Day 3 (26 Feb) may see a slight increase in probabilities dependant on the arrival of the next CME.

Energetic Particles / Solar Radiation: High energy proton flux has a chance of reaching S1/Minor radiation storm levels in response to the recent M3.3 flare. In the absence of any increase from this event, proton flux is most likely to remain at background levels, but with a slight chance of rising in response to any further large flares. High energy electron flux is expected to be mainly at background to moderate levels. The associated 24 hour fluence is expected to remain below the Active (1e8 integrated pfu) threshold.

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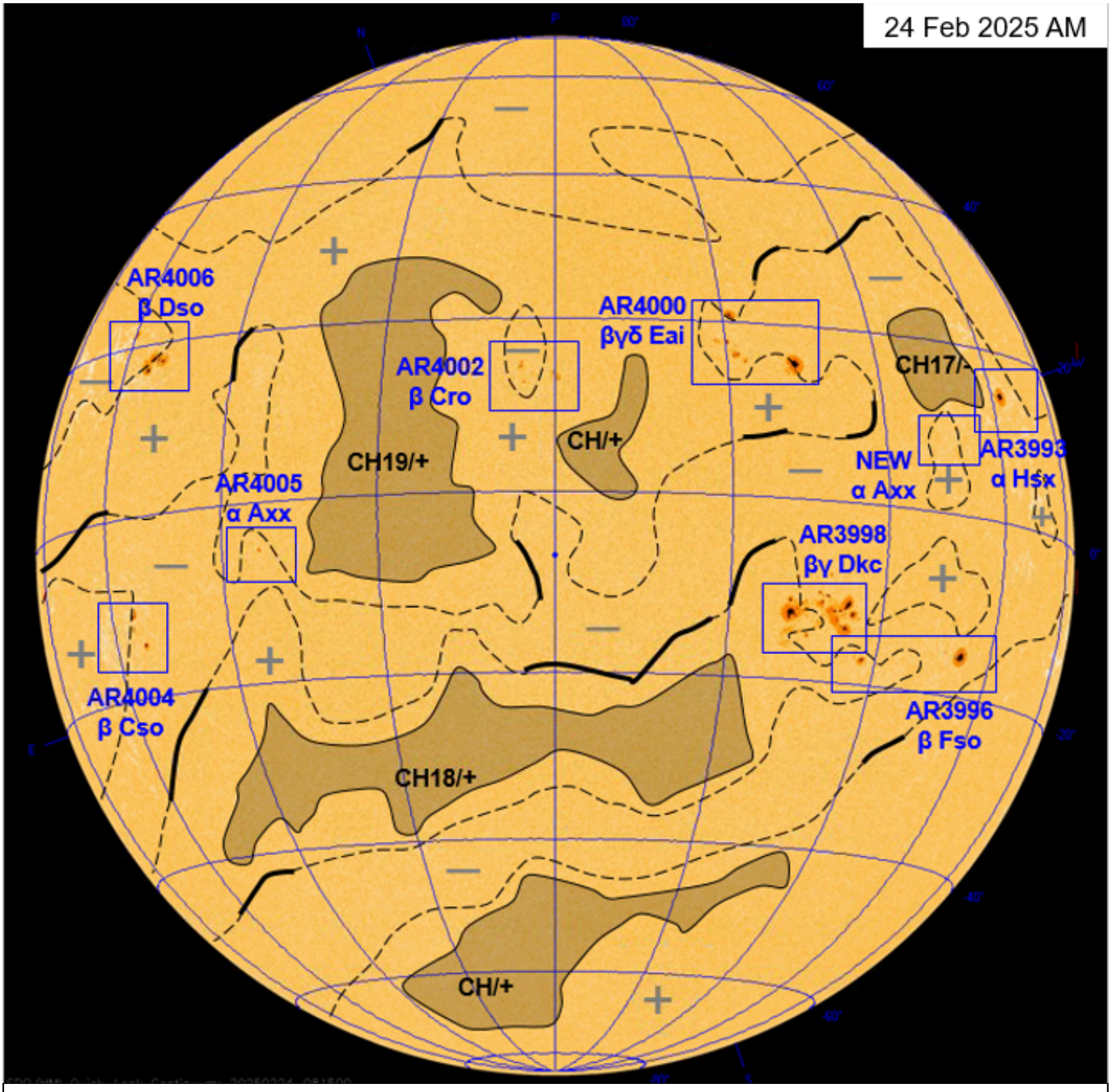
Figure 1: Solar Synoptic Map valid 24/0815 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

There have been several CMEs over the last few days, some of which are difficult to assess in coronagraph imagery. A CME which left the Sun on 20 Feb from near the centre disc may bring a glancing blow to Earth this afternoon, Day 1 (24 Feb). Data from Solar Orbiter suggests this CME could be stronger than the one that left the Sun on 19 Feb which only brought an Unsettled interval on 23 Feb at Earth. However, given Solar Orbiter's position near to Venus, this may miss behind Earths orbit. Confidence is low here. A second CME left the Sun around 24/0700 UTC possibly associated with the M3.3 flare from AR4000 and a filament left off just to the south of this region. This may bring a glancing blow to Earth on Day 3 (26 Feb) but further analysis is required to increase confidence.

Wind speeds are currently at background levels at around 360km/s. Late Day 1 or Day 2 (24-25 Feb) a slight enhancement may occur, associated with CH17/-. This is a small, weak feature seen in imagery, and at most wind speeds may become slightly elevated around 400-450 km/s. As CH17 is negative polarity and the March equinox is approaching, if a connection occurs there may be a slightly greater geomagnetic response to a weak High Speed Stream (HSS) than normally expected. Earth's current position to the south of the solar equator does lessen the chance of any connection however. Larger coronal holes in the eastern hemisphere are unlikely to connect to Earth within this forecasting window, however a number of smaller coronal holes ahead of these have appeared to open up in recent imagery. These have the potential to enhance solar winds towards the end of Day 4 (27 Feb). Enlil is currently overestimating wind speeds and is likely to continue to do so over the next few days.

Initially, geomagnetic activity is forecast to be Unsettled to Active, with a chance of G1/Minor storm intervals and a slight chance of G2/Moderate storm intervals, on Day 1 (24 Feb) however this is generally low confidence due to the uncertainly in the arrival of the CME. Activity then gradually easing back to Quiet to Unsettled from Day 2 (25 Feb). Day 3 (26 Feb) may see a slight increase in probabilities dependant on the arrival of the next CME.

Geomagnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	50	10	20	10
Strong	G3	No	10	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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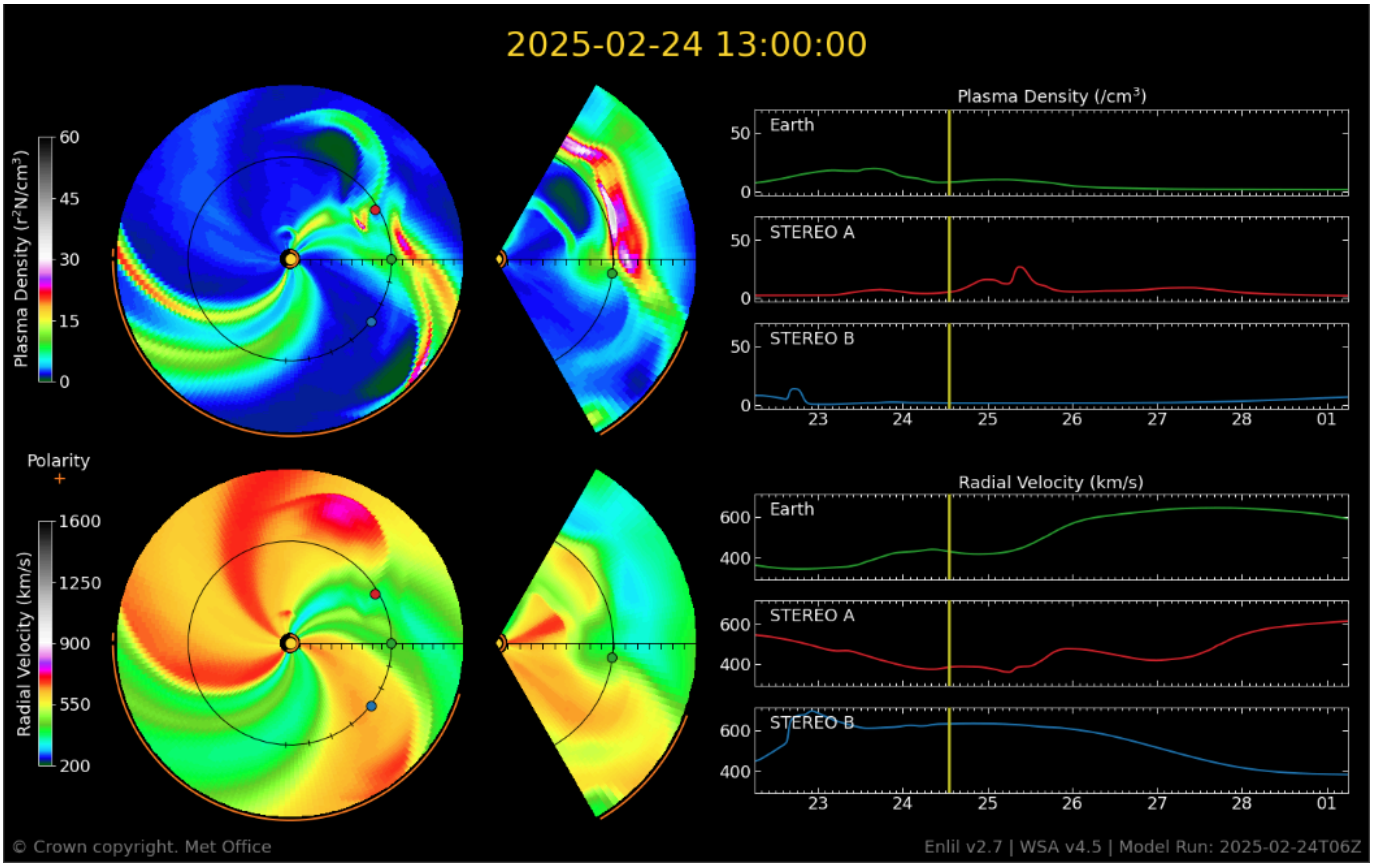
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
20/2200	Partial	Uncertain, maybe near AR3996	Uncertain	450	24/1200UTC +/- 6 hours	Potentially a stronger CME than the first.

Figure 2: MOSWOC Enlil output showing the potential arrival of a CME during Day 1 (24 Feb) and a gradual wind speed increase, which is believed to be too fast in Enlil than reality.



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Radio Blackouts - X-Ray Flares

Solar activity has been High with one X-flare, peaking at X2.0 at 23/1927 UTC, most likely from AR4001 over the NW limb.

There are currently nine sunspot regions on the visible disc. AR3991 has now rotated of the western limb, but potentially still posing a flare risk for the next 24 hours. AR4001 was likely responsible for the largest flare of the last 24 hours, but is no longer visible on the northwest limb. The risk from this region will continue to ease over the next 12 hours. Otherwise, the most notable regions remain AR3998 in the southwest quadrant and AR4000 in the northwest quadrant. AR3998 has shown spot development, increasing in penumbral area, and an increase intermediate spots with mixed polarities. However, it does not currently have a clear delta spot. AR4000 developed rapidly at first although this has now stalled, showing little change in the last 12 hours with some slight decay in its intermediate spots and its delta spot weakening. AR3996 continues to appear to be in slight decay. The other regions on the disc do not currently appear particularly complex, although the regions near the east limb are still difficult to assess accurately due to the foreshortening here.

Moderate solar activity is forecast, with occasional M-flares considered likely and a slight chance of isolated X-flares. There are possibly a couple of further regions due to return from the far side in the coming days, but far side seismographs are not detecting any significant regions near the east limb. As such the probabilities have been kept flat through this period pending further developments.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	70	70	70	70
Very Active	R3-R5 (X Class)	Yes	10	10	10	10

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Figure 3: GOES16&18 X-ray trace in the last 24 hours.

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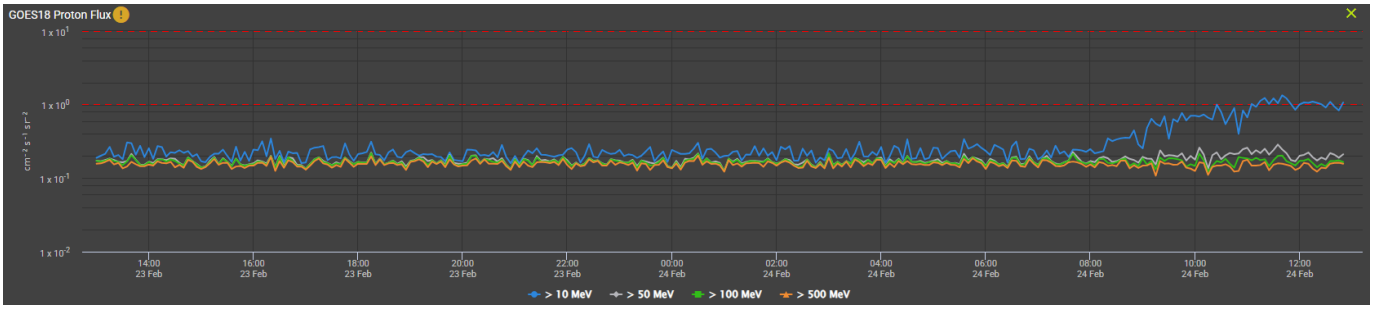
Solar Radiation Storms (High Energy Protons)

GOES18 high energy proton flux is slightly elevated at present, most likely as a response to the M3.3 flare at 24/0702 UTC from AR4000 in the northwest. This may result in a chance of the S1/Minor radiation storm threshold being met during Day 1 (24 Feb), slowly easing into Day 2 (25 Feb).

Overall, proton flux has a chance of reaching S1 levels in response to the recent M3.3 flare. In the absence of any increase from this event, proton flux is most likely to remain at background levels, but with a slight chance of rising in response to any further large flares, the risk mainly from AR3996, AR3998, AR4000, or perhaps AR4001.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	50	30	15	15
Very Active	**≥ S3 ***	No	2	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES 18 Proton flux showing an increase to 1pfu.



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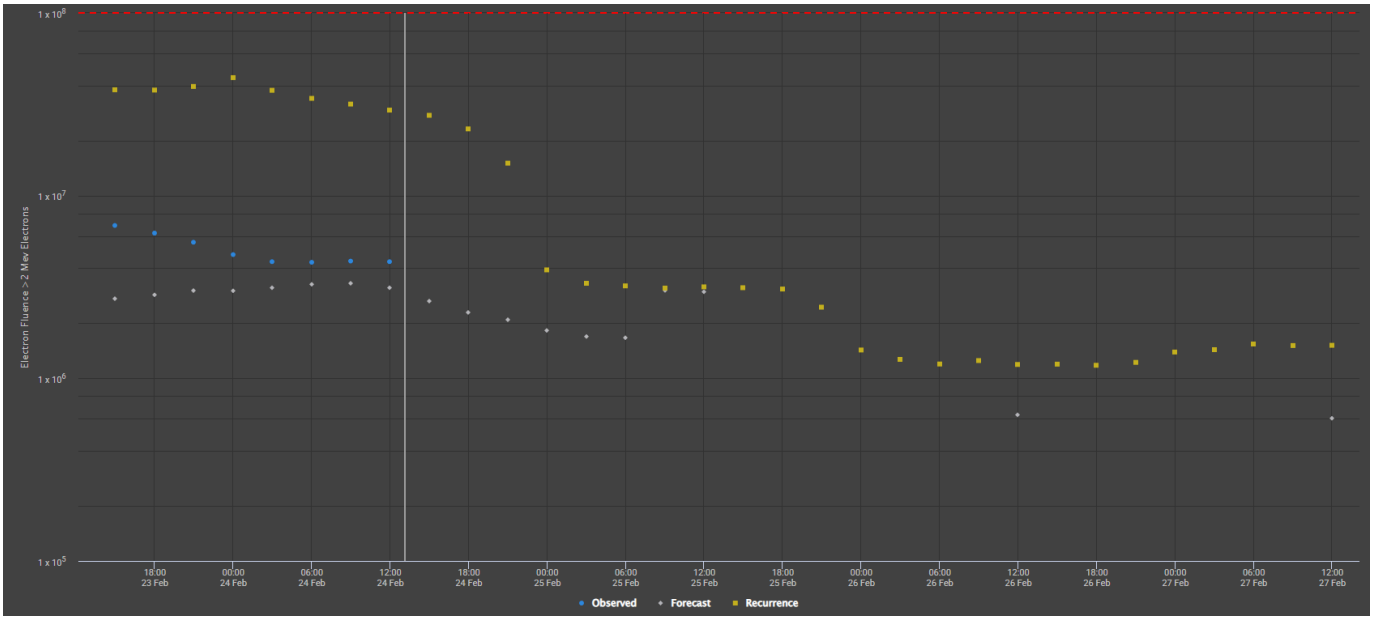
High Energy Electrons (≥ 2MeV)

High energy electron flux, as observed at GOES-16 is at background to diurnally moderate levels. Slow solar winds have become established after the HSS from CH15, and since then there has been no significant rise in electron flux at GEO, so it now seems unlikely that diurnally high peaks will be reached. In addition, with potential CME influence in the forecast on Day 1 (24 Feb), this could help to suppress electron flux during the period.

The associated 24 hour fluence is currently below the Active level, with a slight declining trend. MOSWOC REFM is suggesting a gradual decline in fluence, which matches up with observations and seems like reasonable guidance at this time.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	1	1
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 5: MOSWOC REFM output showing a declining trend in electron fluence.



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